

Guide for Construction of Portland Cement Concrete Pervious Pavement

Foreword

This guide is presented to serve as an aid for designers who are becoming familiar with pervious concrete to be used as a light traffic parking lot pavement and a stormwater management device.

1.0 General Provision

Scope of Work:

The work to be completed under this contract includes the furnishing of all labor, materials, and equipment necessary for construction of the project in conformance with the plans and specifications.

2.0 Reference Documents:

American Society of Testing and Materials

ASTM C 29	Test Method for Unit Weight and Voids in Aggregate
ASTM C 33	Specifications for Concrete Aggregates
ASTM C 42	Test Methods for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 94	Standard Specification for Ready Mix Concrete
ASTM C 117	Test Method for Material Finer than 75 μm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 138	Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
ASTM C 140	Methods of Sampling and Testing Concrete Masonry Units
ASTM C 150	Specifications for Portland Cement (Types I or II only)
ASTM C 172	Practice of Sampling Fresh Concrete
ASTM C 260	Specification for Air-Entraining Admixtures for Concrete
ASTM C 494	Specification for Chemical Admixtures for Concrete
ASTM C 595	Specifications for Blended Hydraulic Cements (Types IP or IS only)
ASTM C 618	Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM D 698	Tests for Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 5.5 Pound Rammer and 12-inch Drop
ASTM C 989	Specification for Ground Granulated Blast Furnace Slag for Use in Concrete and Mortars
ASTM C 1077	Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C1157	Performance Specifications for Hydraulic Cement
ASTM C 1602	Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D 2487	Standard Practice for Classification of Soils for Engineering Purposes
ASTM D 3385	Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer
ASTM E 329	Standard Recommended Practice for Inspection and Testing Agencies for Concrete, Steel and Bituminous Materials as Used in Construction

American Association of State Highway and Transportation Officials (AASHTO)

Use standards comparable to listed ASTM standards

Georgia Department of Transportation (GDOT) Standard Specifications Construction of Transportation Systems

Use standards comparable to listed ASTM standards

American Concrete Institute

ACI 305R Hot Weather Concreting

ACI 306R Cold Weather Concreting

ACI 522 Pervious Concrete

3.0 Contractor Qualifications:

Contractors should meet the requirements of the Georgia Concrete and Products Association (GCPA) Pervious Concrete Contractor Training Program. The requirements of the GCPA program, which incorporates the National Ready Mix Concrete Association's Pervious Contractor Certification Program are:

Pervious Technician

1. Attend GCPA's Pervious Concrete Training Class
2. Successfully complete the NRMCA's Pervious Concrete Technician Exam
3. Attend GCPA's Placement Demo

Pervious Installer:

Level I* :

1. Successful completion of the requirements for GCPA's Pervious Technician
2. Pass the NRMCA Performance Test provided by GCPA.

Level II:**

1. Successful completion of Level I Installer
2. Successful completion of 10 Pervious Concrete installations, at least 3 of which have been tested and met the requirements for thickness and unit weight as outlined below in this specification

Craftsman:** Complete the requirements of NRMCA's Pervious Concrete Craftsman Program.

* Successful installation of Test Panels outlined in this specification are required.

* * Test Panel required only if specified

Proposed Contractors, who have not been through the GCPA training program or a comparable, industry recognized program, must submit credentials and experience to the specifier for review and determination if they satisfy the requirements of the project.

If the placing contractor and concrete producer have insufficient experience with Portland Cement Pervious Concrete Pavement, the placing contractor shall retain an experienced consultant to monitor production, handling, and placement operations at the contractor's expense.

Test Panels:

If the pervious contractor is a GCPA Level I Installer or if directed by the specifier, the pervious contractor is to place, joint and cure two test panels of the lane width that will be used during placement for the project, each a minimum of 225 sq. ft., at the required project thickness, to demonstrate to the specifier's satisfaction that the design criteria can be achieved and a satisfactory pavement can be installed. During placement, the concrete will be tested for density (unit weight) in accordance with ASTM C 138 except that the Jigging Procedure in Section 11 of ASTM C 29 will be used to consolidate the concrete.

Test panels shall be tested for thickness in accordance with ASTM C 42. Two cores shall be taken from each test panel 7 days after placement. After the cores are measured for thickness as described in ASTM C42, they shall be measured for density (unit weight) in the saturated condition as described in Section 8 of ASTM C 140, *Standard Methods of Sampling and Testing Concrete Masonry Units*.

Satisfactory performance of the test panels will be determined by:

Compacted thickness within 1/4" of specified thickness

Void Structure: 15% minimum, 25% maximum or within 4% of the specified void content

Unit weight \pm five (5) pcf of the design unit weight

Visual observation finds no clogging, paste drain down or poorly hydrated paste

If the test panel(s) meets these, it(they) can be left in-place and included in the completed work. If so directed by the specifier or owner, the pervious contractor will remove and dispose of test panels which do not meet specification requirements.

4.0 Concrete Mix Design:

Contractor shall furnish a proposed mix design with proportions of materials to owner or specifier prior to commencement of work. The aggregate data shall include unit weights determined in accordance with ASTM C 29 Section 11, Jigging Procedure.

4.1 MATERIALS:

General:

Locally available material having a record of satisfactory performance shall be used.

Cement:

Portland Cement Type I or II conforming to ASTM C 150, Type IP or IS conforming to ASTM C 595 or Type GU or MS conforming to ASTM C1157 may be used.

Flyash and Ground Iron Blast-Furnace Slag:

Flyash shall conform to ASTM C 618

Ground Granulated Blast-Furnace Slag (GGBFS) shall conform to ASTM C 989

Note: When Flyash or GGBFS is used as part of the minimum cementitious content, strength development may be delayed and additional curing time maybe required. See Section 6.0.

Aggregate:

Use a well graded aggregate with a maximum size no greater than ½" meeting the Deleterious Substances and Physical Property requirements of Class 5M in Table 3 of ASTM C33. Typical acceptable gradations are No. 8 or 89 (max size 3/8 inch) stone meeting ASTM C33 or GDOT gradations. Submit aggregate data to specifier or owner for approval if another gradation is proposed for use on the project.

Air Entraining Agent:

Shall comply with ASTM C 260.

Admixtures:

Shall meet ASTM C494 requirements for Type A Water reducing Admixtures, Type B Retarding or Type D Water Reducing/Retarding

A hydration stabilizer is recommended in the design and production of pervious concrete. This admixture suspends cement hydration and delays initial set. The admixture's primary function should be as a hydration stabilizer; however, it must also meet the requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding Admixtures. Viscosity Modifying Admixtures, which increase the viscosity of the paste, have been used successfully to aid in placement.

Water

Potable or shall comply with ASTM C 1602 or GDOT Standard Specifications.

4.2 PROPORTIONS:

Cement Content:

For pavements subjected to vehicular traffic loading, the total cementitious material shall not be less than 600 lbs. per cu. yd. Flyash may be used in amounts not to exceed 25% of total cementitious material. GGBFS may be used in amounts not to exceed 50% by weight of total cementitious material. Slag content should be reduced to 30% when ambient temperatures fall below 50 F. If a ternary mix is used, the total replacement shall not exceed 50% of the mass of the Portland cement.

Aggregate Content:

The volume of aggregate per cu. yd. shall be equal to 27 cu. ft. when calculated as a function of the bulk unit weight determined in accordance with ASTM C 29, Jigging

Procedure. If used, fine aggregate should not exceed three (3) bulk cu. ft., based on unit weight obtained by the Jigging Procedure, and shall be included as part of the 27 cu. ft of total aggregate volume.

Admixtures:

Follow the manufacturer's instructions and recommendations.

Mix Water:

Mix water quantity shall produce a fully wetted paste with high viscosity. This condition occurs when the cement paste displays a wet, metallic sheen and does not flow from the aggregate. An insufficient amount of water yields a cement paste with a dull-dry appearance and insufficient water for hydration.

Insufficient water results in poor bond strength while high water content results in the paste draining off the aggregate, sealing the bottom of the pervious concrete and causing a weak pavement surface.

5.0 SUBGRADE PREPARATION AND FORMWORK:

Subgrade Material:

The top 6 inches shall be composed of free draining, granular or gravelly soil that is predominantly sandy with no more than a moderate amount of silt or clay. Where this type of subgrade is not present, a separation layer of non woven geotextile fabric shall be placed on the subgrade followed by a zone of clean gravel, such as #57 stone. This zone is referred to as the recharge bed.

Subgrade Permeability:

Prior to placement of Portland Cement Pervious Pavement, the subgrade shall be tested for rate of permeability by double ring infiltrometer (ASTM D 3385), or other suitable test of subgrade soil permeability. The tested permeability must meet the requirements of the project designer.

Subgrade Support:

The subgrade shall be compacted by a mechanical vibratory compactor to a minimum density of 95% of the maximum dry density as established by ASTM D 698 or AASHTO T 99. Subgrade permeability is inversely proportional to compaction so care should be taken to avoid compaction levels that prevent the subgrade from providing the permeability assumed in the design.

If fill material (embankment) is required to bring the site to subgrade elevation, it shall be clean and free of deleterious materials. It shall be placed in accordance with the geotechnical engineer's recommendations and/or the project specifications. The subgrade shall be firm, compacted, in a moist condition with no mud or standing water.

Forms:

Forms may be of wood or steel and shall be the depth of the pavement. Forms shall be of sufficient strength and stability to not deform under the stresses caused by mechanical equipment used in spreading, strike-off and compaction operations.

6.0 MIXING, HAULING AND PLACING:

Pervious Concrete should be produced, delivered and discharged in accordance with ASTM C 94. It is important that mixer trucks meet the Concrete Uniformity Requirements of Annex A1 of C 94.

Mix and Placement Time:

Truck mixers shall be operated at the speed designated as mixing speed by the manufacturer for 75 to 100 revolutions of the drum. Placement, screeding, compacting and jointing of the concrete mixture must be completed within one (1) hour of the introduction of mix water, unless otherwise approved by the owner or specifier. This time can be increased to 90 minutes when utilizing the hydration stabilizer specified in Section 4.1 or when cool, humid and calm weather conditions exist.

Discharge:

Each mixer truck will be inspected for appearance of consistency described in 4.2 and for concrete uniformity. Water may be added to obtain the required mix consistency. A minimum of 20 revolutions at the manufacturer's designated mixing speed shall be required following any addition of water to the mix. Discharge shall be a continuous operation and shall be completed as quickly as possible. Concrete shall be deposited as close to its final position as practicable and such that fresh concrete enters the mass of previously placed concrete. The practice of discharging onto subgrade and pulling or shoveling to final placement is to be avoided.

Placing and Finishing Equipment:

The contractor will be restricted to pavement placement widths of a maximum of fifteen (15) feet unless the contractor can demonstrate competence in constructing greater pavement placement widths to the satisfaction of the owner or specifier.

Unless otherwise approved by the owner and specifier in writing, the contractor, shall provide mechanical equipment of either slipform or form riding with a following compactive unit that will provide a minimum of 10 psi vertical pressure. If placing equipment does not provide the minimum specified vertical force, a full width roller or other full width compaction device that provides sufficient compactive effort shall be used immediately following the strike-off operation.

It is typical that riser strips are attached to the top of the form to allow the screeding/strike-off equipment to level the concrete $\frac{1}{4}$ to $\frac{1}{2}$ inch thick above design top of pavement. The mix design, pavement thickness and compactive effort will determine how far the screed elevation is above top of pavement. After screeding, the riser strips are removed and compaction rollers consolidate the concrete to finish grade. Cross rolling may be required to obtain the required pavement surface planeness. The pervious concrete pavement will be placed to the required cross section and shall not deviate more than $\pm \frac{3}{8}$ inch in 10 feet from profile grade.

After the compaction operation, no other finishing operation will be allowed. If vibration is used, it shall be shut off immediately when forward progress is halted for any reason.

Jointing:

Transverse control (contraction) joints shall be installed at 20 foot intervals. They shall be installed at a depth of at least $\frac{1}{4}$ the thickness of the pavement. Longitudinal control joints shall be installed at the midpoint of the placement if the constructed lane width exceeds 20 feet. Where joints are installed, it is highly recommended that they be cut into the fresh concrete during placement using a "pizza cutter" roller specifically constructed for

the purpose. If saw cut, the procedure should begin as soon as the pavement has hardened sufficiently to prevent raveling and uncontrolled cracking (normally after curing).

Transverse construction joints shall be installed whenever placing is suspended a sufficient length of time that concrete may begin to harden. In order to assure aggregate bond at construction joints, a bonding agent suitable for bonding fresh concrete to existing concrete shall be brushed, rolled, or sprayed on the existing pavement surface edge. Isolation (expansion) joints will not be used except when pavement is abutting slabs or other adjoining structures.

Curing:

Curing procedures shall begin immediately following placement operations. The pavement surface shall be covered with a minimum six (6) mil thick polyethylene sheet or other approved non absorptive, water impermeable covering material within 30 minutes of concrete discharge from the truck. Prior to covering, a fog or light mist shall be sprayed above the surface when required to replace water which evaporated due to ambient conditions (temperature, wind, and low humidity). The cover shall overlap all exposed edges and shall be thoroughly secured (without using soil or other fine material which is subject to be displaced by wind or water) to completely encapsulate the pervious concrete and to prevent dislocation due to winds or adjacent traffic conditions.

Due to the porosity of pervious concrete allowing dissipation of its heat of hydration, it is critical that cold weather concrete practices stipulated in ACI 306 be used when cooler temperatures are experienced during construction.

Cure Time:

The polyethylene curing sheet shall be left in place for the durations shown:

Portland Cement Type I, II or IS; Hydraulic Cement Type GU or MS - 7 days minimum

GGBFS or Class F Flyash as part of the 600 lbs./cy minimum cementitious or Type IP - 10 days minimum unless test data indicates that the concrete reaches sufficient maturity at an earlier age

No truck traffic shall be allowed for 10 days (no passenger car/light trucks for seven (7) days) or the minimum cure time is reached.

7.0 TESTING, INSPECTION AND ACCEPTANCE:

Laboratory Qualification:

The owner will retain an independent testing laboratory which shall conform to the applicable requirements of ASTM E 329, *Standard Recommended Practice for Inspection and Testing Agencies for Concrete, Steel, and Bituminous Materials as Used in Construction*, and ASTM C 1077, *Standard Practice for Testing Concrete and Concrete Aggregates for Use in Construction, and Criteria for Laboratory Evaluation*, and shall be inspected and accredited by a recognized national authority.

The agent of the testing laboratory performing field sampling and testing for concrete shall be certified by the American Concrete Institute as a Concrete Field Testing Technician Grade I, or be of an equivalent level of competence as certified by a recognized state or national authority. It is highly recommended that the agent be a certified NRMCA Pervious Technician.

Testing and Acceptance:

A minimum of one soil classification test in accordance with ASTM C2487 shall be performed for each day's placement of pervious concrete.

A minimum of one sample for each days placement shall be taken in accordance with ASTM C 172. Delivered unit weights are to be determined in accordance with ASTM C 29, paragraph 11, Jigging Procedure, using at least a 0.25 cubic foot cylindrical metal measure. The unit weight of the delivered concrete shall be \pm five (5) pcf of the mix design unit weight.

A minimum of seven (7) days after each placement, three cores shall be taken in accordance with ASTM C 42. The cores shall be measured for thickness and unit weight and visually observed as described above for Test Panels. Core holes shall be filled with concrete meeting the pervious mix design.

The average of all production cores shall not be less than the specified thickness with no individual core being more than 1/2 inch less than the specified thickness. The average void content of the cores shall be within 4% of the specified void content with no individual void content being less than 15% or 5% greater than the specified void content. Visual observation shall find no clogging, paste drain down or poorly hydrated paste.

SPECIAL NOTE: *This information is intended to be used by the design professional competent to evaluate its significance and limitation and who will accept the responsibility for its proper application. The Georgia Concrete and Products Association disclaims any and all responsibility for any other use of the information supplied herein.*

Revised August 2006